Phosphate in Cells - An Indispensible Biomolecule

What is Phosphate?

Phosphorus is an element with the atomic number 15, which has the unique property of being able to form up to five bonds with neighboring atoms. This allows it to form a unique compound, the Phosphate Anion $\mathbf{[PO_4]^{3-}}$, consisting of a phosphorous surrounded by three single bonded oxygens and one double-bonded oxygen. In the cytosol, free phosphates are typically in the form $\mathbf{[H_2PO_4]^-}$ and $\mathbf{[HPO_4]^{2-}}$, and are usually denoted Pi, for inorganic phosphate. Inorganic in this context simply means that the compound does not contain carbon-hydrogen bonds[1].

Inorganic Phosphate in Metabolism and Cell Signalling

Inorganic phosphate has a variety of uses throughout the cell. The most notable being as a form of energy storage in the molecule ATP, Adenosine Triphosphate, where energy is stored in bonds between the nucleoside adenosine and a chain of Pi. The chain of Pi forms high energy bonds due to their electronegativity. This Pi can then be transferred to proteins to activate them or change their function, a process known as phosphorylation, which allows thing such as muscle contraction, neurotransmission, and active transport of ions against the concentration gradient[2]. Nucleoside triphosphates are also used to provide energy for DNA transcription. One nucleoside triphosphate in particular, Guanosine triphosphate, is ubiquitous in cells and functions similarly to ATP, and can readily be converted into it. Guanosine triphosphate is strongly associated with G-proteins, which are proteins which bind to and convert GTP to GDP. G-proteins are an integral part of many cellular processes, including initiating intracellular signalling cascades from receptors that bind various hormones, neurotransmitters, and peptides, regulating the activity of various proteins and DNA transcription[3].

Phospholipids - An integral part of the cell membrane and more

Phospholipids are a unique class of biomolecules which have both hydrophillic (polar) and hydrophobic (nonpolar) moieties. Phospholipids form a bilayer in the membrane of every cell, with the hydrophillic portions facing outwards towards the extracellular space and the cytosol, and the hydrophobic portions facing into the membrane. The hydrophobic portion is a chain of 2 hydrophobic lipids, one containing a double bond, typically attached to glycerol, and the hydrophillic moiety, one of a variety of molecules including choline, ethanolamine, serine, inositol, and glycerol. Joining these two moieties together is our beloved phosphate molecule, which acts as a bridge, bonding one of its oxygens to each moiety. In addition to forming the membrane of every cell in the body, phospholipids contribue to other cellular functions, such as

intracellular signalling, acting as a surfacant in the lungs, and acting as mediators in the cellular inflammatory process[4].

Multilamellar Organelles - A new organelle discovered within the past year!

Recent research from 2023 shows evidence for a new cell organelle. Dubbed PXo bodies after a Pi transporter protein, these multilamellar organelles found in cells in the fruit fly digestive tract appear to act as a storage for inorganic phosphate, as opposed to the vacuoles found in plants and bacteria[5]. When researchers starved the flies of phosphate, PXo bodies were broken down to release Pi into the cytosol. This was coupled with increased cell proliferation in the digestive tract, which is unexpected but could possibly be explained by these cells attempting to divide to absorb more phosphate from food[6].

References

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